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MARSHALL PROCEDURES AND GUIDELINES

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MSFC RADIATION PROCEDURES AND GUIDELINES

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PREFACE

P.1 PURPOSE

This document establishes centralized control over the use of ionizing radiation sources to ensure that exposure is adequately controlled to prevent adverse effects on the health and safety of employees.

P.2 APPLICABILITY

This Directive is applicable to all onsite Marshall Space Flight Center (MSFC) operations, including contractor operations involving the use of radioactive material or radiation-producing devices.

P.3 AUTHORITY

a. MPD 1840.1, “MSFC Environmental Health Program”

b. MPD 1860.2, “Radiation Safety Program”

c. 10 CFR Part 20, “Standards for Protection Against Radiation”

d. 10 CFR Part 30, “Rules of General Applicability to Domestic Licensing of Byproduct Material”

e. 10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities”

f. 29 CFR 1960, “Basic Program Elements for Federal Employee Occupational Safety and Health Programs and Related Matters”

g. 49 CFR Sub Part I (173.401-173.476), “Transportation, Class 7 (Radioactive Materials)”

h. Alabama Department of Public Health Rule 420-3-26, “Radiation Control”

P.4 APPLICABLE DOCUMENTS

a. MWI 5100.1, “Procurement Initiators Guide”

b. MWI 8621.1, “Close Call and Mishap Reporting and Investigation Program”

P.5 REFERENCES

a. MPG 8715.1, “Marshall Safety, Health, and Environmental (SHE) Program”

b. MWI 8715.6, “Hazardous Operations”

c. MWI 3410.1, “Personnel Certification Program”

d. MWI 8715.2, “Lockout/Tagout Program”

P.6 CANCELLATION

None

Original Signed by
Axel Roth for

A. G. Stephenson
Director

DOCUMENT CONTENT

1. DEFINITIONS

1.1 Airborne Radioactive Material. Airborne radioactive material in any form such as dust, mist, or gas.

1.2 Alpha Particle. The nucleus of the helium atom, He-4, a particle with a mass of four consisting of two protons and two neutrons and having two units of positive charge; commonly ejected during decay of some naturally occurring isotopes.

1.3 Beam. An approximately unidirectional flow of electromagnetic or particulate radiation.

1.3.1 Useful Beam. That part of the primary radiation which passes through the cone, aperture, or other collimating device.

1.4 Beta Particle. A particle, having the mass and charge of an electron, emitted from the nucleus of an atom; most common in artificially produced isotopes.

1.5 Bremsstrahlung. Secondary photon radiation produced by deceleration of charged particles passing through matter.

1.6 Byproduct Material. Any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident to the process of producing when using special nuclear material.

1.7 Code Designator. A coding system that identifies each separate film packet with a specific period of time, the user installation, and the wearing individual.

1.8 Collimator. A device for confining a beam of particles or rays within a defined cross section.

1.9 Contamination, Radioactive. Radioactive material deposited in any undesired place and particularly any place where its presence may be harmful.

1.10 Controlled Area. Any area whose access is restricted by the user for the purpose of limiting radiation exposure.

1.11 Count (Measurement of Radiation). The external indication of a device designed to enumerate ionizing events; it may refer to a single detected event or to the total events registered in a

given period of time; the term is loosely used to designate disintegration, an ionizing event, or a voltage pulse.

1.12 Counting Rate Meter. A device that gives a continuous indication of the average rate of ionizing events.

1.13 Curie. That quantity of a radioactive nuclide disintegrating at the rate of 3.7×10^{10} atoms/second. Metric equivalent is the becquerel (Bq). One becquerel is one disintegration per second.

1.14 Dose. According to current usage, the radiation delivered to a specified area, volume, or the whole body. Units for dose specification are roentgens for x- or gamma rays, rads or equivalent roentgens for beta rays, and rems for neutrons. In radiology, the dose may be specified in air, on the skin, or in some depth beneath the surface; no statement of dose is complete without specification of location. In recent years there has been an increasing tendency to regard a dose of radiation as the amount of energy absorbed by tissue at the site of interest per unit mass. Metric equivalent is the sievert (Sv). One sievert equals 100 rem.

1.14.1 Absorbed Dose. The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest; the special unit of absorbed dose is the rad; one rad equals 100 ergs/gram. The metric equivalent is the gray (Gy). One gray equals 100 rad.

1.15 Dose Rate. Radiation dose delivered per unit time.

1.16 Dose Rate Meter. Any instrument that measures radiation dose rate.

1.17 Dosimeter. A device used to detect and measure an accumulated dose of radiation [e.g., (Thermo Luminescent Dosimetry Badge (TLD badge), finger ring].

1.18 Dosimetry. Determination of the cumulative dosage of radiation by using a dosimeter.

1.19 External Radiation. Exposure to ionizing radiation when the source is outside the body.

1.20 Gamma Rays. Short wavelength electromagnetic radiation of nuclear origin with wavelengths of 10^{-8} to 10^{-11} centimeters emitted from the nucleus; usually monoenergetic for a particular radio nuclide.

1.21 Half-Life, Radioactive. Time required for a radioactive substance to lose 50 percent of its activity by decay; each radioactive substance has a unique half-life.

1.22 High Radiation Area. An area where an individual might receive 100 millirem in one hour at 30 centimeters from the radiation source.

1.23 Interlock. A device, usually electrical and/or mechanical in nature, that prevents activation of a system until a preliminary condition has been met or prevents hazardous operations; its purpose usually is safety of personnel or equipment; for example, an interlock may be provided to prevent activation of a radiographic system until all access doors have been closed.

1.24 Ionizing Radiation. Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter.

1.25 Licensed Material. Source material, special nuclear material, or byproduct material that is authorized for use by the NRC.

1.26 Millicurie. 0.001 curie the amount of radioactive material that disintegrates at the rate of 37 million atoms/second.

1.27 Millirem. A sub multiple of the Roentgen Equivalent Man (REM), 0.001 REM.

1.28 Monitoring. Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination present in an occupied region as a safety measure for purposes of health protection.

1.29 Monitoring Period. The length of time during which a badge is worn by the individual being monitored; usually, TLD badge service is furnished each calendar quarter.

1.30 Rad. The unit of absorbed dose (100 ergs/gram); measure of energy imparted to matter by ionizing particles per unit of mass of irradiated material at the point of interest.

1.31 Radiation. The energy propagated through space or through a material medium as waves; for example, energy in the form of electromagnetic waves or elastic waves. The term radiation or radiant energy, when unqualified, usually refers to electromagnetic radiation; such radiation commonly is classified, according to frequency, as radio, infrared, visible (light),

ultraviolet, x-ray, and gamma ray. By extension, corpuscular emission, such as alpha and beta radiation, or rays of mixed or unknown type, such as cosmic radiation.

1.32 Radiation Area. An area where an individual might receive 5 millirem in an hour at 30 centimeters from the radiation source.

1.33 Radiation Protection Guides (RPG). That radiation dose level which a person should not be exposed in a specified interval of time without careful consideration of the reasons for doing so.

1.34 Radioactive Material. Any material, whether or not under licensing control of the NRC, that emanates electromagnetic and/or particulate radiations capable of producing ion pairs in the absorbing medium; includes both naturally occurring radioactive elements as well as byproduct, source, and special nuclear material.

1.35 REM (Roentgen Equivalent Man). A unit of measurement of ionizing radiation dose to body tissue in terms of its estimated biological effect related to a dose of 1 roentgen of x-rays [1 millirem (mrem) = 0.001 REM]. The relation of the REM to the other dose units depends upon the biological effect under consideration and upon the conditions of irradiation. For this regulation, any of the following is considered equivalent to a dose of 1 REM:

1.35.1 An exposure of 1 roentgen due to x- or gamma radiation

1.35.2 A dose of 1 rad due to x-, gamma, or beta radiation

1.35.3 A dose of 0.1 rad due to neutrons or high-energy protons

1.35.4 A dose of 0.05 rad due to particles heavier than protons with sufficient energy to reach the lens of the eye

It is more convenient to measure the neutron flux, or equivalent, than to determine the neutron dose in rads; provided in 1.35.3, 1 REM of neutron radiation, for this regulation, is assumed equivalent to 14 million neutrons/square centimeter incident on the body; or if there exists sufficient information to estimate with reasonable accuracy the approximate distribution in energy of the neutrons, the incident number of neutrons per square centimeter equivalent to 1 REM may be estimated from the following table.

Neutron Energy (MeV)	No. of Neutrons/cm^2 equivalent to a Dose of 1 REM(neutrons/cm^2)	Average Fluence to Deliver 100 millirem in 40 hours (neutrons/cm^2)
Thermal	970×10^6	670
0.0001	720×10^6	500
0.005	820×10^6	570
0.02	400×10^6	280
0.1	120×10^6	80
0.5	43×10^6	30
1.0	26×10^6	18
2.5	29×10^6	20
5.0	26×10^6	18
7.5	24×10^6	17
10.0	24×10^6	17
10.0-30.0	14×10^6	10

1.36 Restricted Area. See Controlled Area (Section 1.10).

1.37 Roentgen (R). That quantity of x- or gamma irradiation that produces 1 statcoulomb of negative ions and 1 statcoulomb of positive ions at 0^o C and 760 millimeters of mercury pressure in 1 cubic centimeter of air; IR = 83 ergs/gram-mass = 2.083×10^4 ion pairs/cubic centimeter of air (standard temperature and pressure (STP)) = 1 electrostatic unit/ cubic centimeter of air (STP) = 1.61×10^{12} ion pairs/gram-mass air = 6.8×10^4 mega-electron-volts/cubic centimeter of air (STP).

1.38 Sealed Source. Any radioactive material encased in, and is to be used in, a container in a manner intended to prevent leakage of the radioactive material or any of its daughter products.

1.39 Source Material. Any material, except fissionable material, containing by weight one-twentieth of 1 percent (0.05 percent) or more of (a) uranium, (b) thorium, or (c) any combination thereof.

1.40 Special Nuclear Material. (a) Plutonium, uranium enriched in the isotope 233 or in the isotope 235, and any other material that the NRC determines to be special nuclear material, not including source material; or (b) any material artificially enriched by any of the foregoing, not including source material.

1.41 Survey, Radiological. Evaluation of the radiation hazards incident to the production, use, or existence of radioactive materials or other sources of radiation under a specific set of conditions; such evaluation customarily includes a physical survey of the disposition of materials and equipment, measurements of estimates of the levels of radiation that may be involved, and a sufficient knowledge of processes using or affecting these materials to predict hazards resulting from expected or possible changes in materials or equipment.

1.42 Thermo Luminescent Dosimetry (TLD) Badge. A pack of thermo luminescent material capable of both storing energy when heated from absorption of ionizing radiation and releasing this energy in the form of visible light. The amount of light can be used as a measurement of absorbed dose.

1.43 TLD Evaluation. Readout of the TLD material to obtain dosage readings.

1.44 Very High Radiation Area. Any area accessible to personnel, where the dose rate at 1 meter from the source or any surface from which it penetrates exceeds 500 Rad/hr.

1.45 X-Ray Area. Any area where an x-radiation hazard exists.

2. RESPONSIBILITIES

2.1 Manager, Management Support Office, through Occupational Medicine and Environmental Health Services (OMEHS), will:

2.1.1 Designate a Radiation Safety Officer (RSO) and an alternate to coordinate the Radiation Safety Program, serve as member and secretary of the Radiation Safety Committee (RSC), and perform those functions outlined in this document. The RSO will develop material for the RSC review and include in this document when revisions are made.

2.1.2 Conduct preassignment medical examinations and advise individuals assigned to radiation work.

2.1.3 Conduct periodic medical examinations and arrange for treatment of personnel exposed to excessive radiation.

2.1.4 Provide for dosimetry service for measuring personnel exposure to radiation.

2.1.5 Make required special surveys of radiation areas and advise the RSC on the effectiveness of the program.

2.1.6 Maintain records of radiation exposure of each individual and monitor the accumulated exposure. Provide this information quarterly (for ALARA purposes) to all participants in the program or as required by the Nuclear Regulatory Commission (NRC).

2.1.7 Provide a physician as an advisory member to the RSC.

2.1.8 Coordinate the repair and calibration of portable radiation survey instruments at least every 6 months. If an instrument cannot be repaired, tag the instrument properly.

2.2 Manager, Facilities Engineering Department (FED), is responsible for ensuring that plans for construction or modification of facilities and equipment involving storage or use of sources of ionizing radiation are approved by the RSC prior to starting construction or modification work.

2.2.1 Provide calibration of portable radiation survey instruments.

2.3 Director, MSFC Safety and Mission Assurance (S&MA) Office, is responsible for providing a representative to serve as a member of the RSC.

2.4 Directors/Managers/Group Leads/Team Leads will ensure that:

2.4.1 Responsibility for every radioactive source used for research and development is clearly assigned to an “authorized user.”

2.4.2 Each authorized user is trained to understand his/her responsibilities and the hazards associated with any ionizing-radiation-producing equipment or material under his/her control.

2.4.3 All laboratory personnel are adequately familiar with radiological hazards and regulations.

2.4.4 Facility Organizational Work Instructions (OWI) clearly define procedures for operating ionizing-radiation-producing equipment and for performing and documenting periodic checks of the safety systems of the facility.

2.4.5 Facility OWIs clearly define the line of radiation safety responsibility.

2.4.6 All portable radiation survey instruments are calibrated according to schedule and repaired as required.

2.4.7 All portable radiation survey units deemed “not repairable” are replaced as soon as possible.

2.4.8 All radioactive sources included in the design of his/her equipment are identified.

2.4.9 Each source is reviewed to:

2.4.9.1 Establish its necessity

2.4.9.2 Ensure that the design and procedures optimize safety.

2.4.10 The list of radioactive sources is sent to the RSO.

2.5 The Radiation Safety Officer (RSO) will:

2.5.1 Train personnel in the safe use of radioactive materials and radiation-producing devices, both before initial approval of radiation work and annually as required by NRC regulations.

2.5.2 Keep this radiation safety procedure document current.

2.5.3 Perform an annual audit of compliance with this document and with relevant state and/or federal regulations.

2.5.4 The RSO will coordinate the Radiation Safety Program between users and the RSC. The RSO will serve as secretary of the RSC and will maintain all records pertaining to the Radiation Safety Program. The RSO will keep the RSC informed at all times of the status of the Radiation Safety Program and will perform the following duties:

2.5.4.1 Provide an annual detailed radiation safety report to the RSC (in hardcopy form). In addition, provide quarterly status reports to the RSC.

2.5.4.2 Review plans of proposed operations involving the use of radiation to ensure that adequate protective measures are incorporated into the layouts and engineering drawings, and consult with the RSC on these matters. New state-of-the-art activities may require consultation with independent experts.

2.5.4.3 Assist operating segments in developing operating procedures for radiological operations.

2.5.4.4 Perform periodic surveys of radioactive material areas and radiation-producing devices or installations (at least every 6 months) to ensure that the degree of radiation protection provided is adequate and conform to the provisions of 10 CFR 20,

"Standards for Protection Against Radiation," and the provisions of this Directive.

2.5.4.5 Assist in the performance of leak tests on sealed sources.

2.5.4.6 Impound radioactive material, as appropriate, and stop unsafe practices as discussed in Chapter 15 of this document.

2.5.4.7 Seal off contaminated areas.

2.5.4.8 Require tests of potentially contaminated personnel.

2.5.4.9 Approve all procurements and shipments of radioactive material and associated documentation.

2.5.4.10 Approve purchase requests for all radiation-producing devices (MWI 5100.1).

2.6 The Director, Procurement Office, will

2.6.1 Ensure that contractors from whom radioactive materials are purchased are required to request shipping instructions from the MSFC RSO prior to shipment.

2.6.2 Ensure proper approval of procurement documents per MWI 5100.1 prior to the purchase of any radioactive materials.

3. PROCEDURE

See Chapters 1-15.

4. RECORDS

The following records will be maintained and dispositioned by Environmental Health Services in accordance with 10 CFR 20 Subpart L, and 29 CFR 1910.1020. Following the retention period, the documents will either be destroyed or maintained for historical purposes.

MSFC Form 4414, "Radiation User Approval"
MSFC Form 4415, "Radiation Machine Use Authorization"
MSFC Form 4416, "Radiation Material Use Authorization"
NRC Form 5, "Occupational Dose Record for a Monitoring Period," or equivalent
NRC Form 4, "Cumulative Occupational Dose History," or equivalent

5. FLOW DIAGRAM

None

CHAPTER 1

GENERAL PROCEDURES

CH1.1 General Procedures

CH1.1.1 The RSC will approve the use of radioactive material and/or radiation-producing devices, as appropriate. The approval level will be determined based on such information as: complexity of operation, state-of-the-art knowledge, and experience level of user group. The supervisor/principal operator of any MSFC or MSFC contractor facility/project engaged in work with radioactive materials or devices must prepare a letter or other appropriate documentation and submit same to the RSO/RSC requesting proper approval. The request must contain such items as names and qualifications of proposed user(s), material (type and quantity) or device to be used, location of proposed operation, copies of procedures to be followed, and radiation-monitoring instruments available. After this request has been approved, the user may proceed with plans to procure the material or device as outlined in Chapter 2. The RSO will maintain records of approval/disapproval.

CH1.1.2 It is unnecessary for projects having once obtained approval to repeat the process in the future unless the project has evolved into an operation beyond the initial scope/intent/complexity presented to the RSC. Should this occur, then a supervisor or principal operator should contact the RSC and follow its advice as to the necessity of further approval.

CH1.2 Facilities Engineering Department (and Facilities Engineering prime/subcontractors)

All outside radiographers using radioactive materials or x-ray sources must report to the MSFC RSO, Building 4249, Room 116, prior to performing any work at MSFC. At that time, all documentation and instrumentation will be checked and if any is not in proper order, the radiographer will be denied access to perform work at MSFC. Access will be denied until copies of proper forms are available for review. Other procedures will be reviewed at the same time.

THE USER IS RESPONSIBLE FOR COMPLIANCE WITH REGULATIONS IN THIS DOCUMENT

CH1.3 Radiation Safety Committee (RSC)

CH1.3.1 The RSO will receive the requests previously discussed and, as soon as possible after the receipt of the request, the committee will convene, as appropriate, and review the request. Items such as personnel qualifications, adequacy of facilities, preparation of operating procedures, etc., will be considered in the review. The RSC will ensure that users are aware that they must follow the provisions of 10 CFR Title 1 Part 20, "Standards for Protection Against Radiation," in all operations involving radiation, whether they be radioactive material or radiation-producing devices.

CH1.3.2 After the RSC determines the radiation protection requirements for a given operation are adequate, a written reply will be prepared by the RSO outlining in detail the conditions that must be followed by the individual or individuals concerned.

CH1.3.3 After the operation commences, the RSO will periodically perform an inspection to ensure that provisions of radiation protection are being followed.

CH1.3.4 If a request is received for material in quantities, in types, or for uses that are not covered in the NRC MSFC License, the RSO/RSC will apply for an amendment to the existing license to allow a greater quantity, a different type, or a different use. In no case will the RSO/RSC allow the use of material in quantities or types not covered by the license. In cases that cannot be covered by the NRC License, the RSO/RSC will make certain that an application for a separate license is submitted to the NRC.

NOTE: AMENDMENTS USUALLY REQUIRE AT LEAST A 90-DAY LEAD TIME.

CH1.3.5 The RSC will maintain oversight of Centerwide radon monitoring status, radiation training efforts, and other activities associated with radiation protection.

CH1.3.6 Membership of the RSC will be as follows:[1]

CH1.3.6.1 The MSFC Radiation Safety Officer

[1] The names and qualifications of the Chairman, Radiation Safety Officer, and all users are part of the license application. Any changes must be coordinated with the NRC.

CH1.3.6.2 Representatives appointed by the MSFC Center Director who have training and experience in the safe use of radioactive materials and radiation-producing devices

CH1.3.6.3 One member supplied by the MSFC Safety and Mission Assurance (S&MA) Office

CH1.3.6.4 One member appointed as Chairman

CH1.3.6.5 One member from the Facilities Engineering Department

CH1.3.6.6 MSFC Occupational Health Officer

CH1.3.6.7 Contracting Officers Technical Representative (COTR) for Occupational Medicine and Environmental Health Services contract

CH1.3.7 There shall be at least five members appointed. In addition, each member shall normally have a designated alternate. Members shall serve on the RSC as an additional responsibility to their regular job requirements.

CH1.4 MSFC Radiation Safety Program Document

CH1.4.1 Preparation and maintenance of the MSFC Radiation Safety Procedure Document will be the responsibility of the Manager, Management Support Office, in conjunction with the RSC. The document will establish detailed policies, procedures, standards, and guidelines to be followed in ensuring proper radiological health and safety controls, compliance with NRC regulations, and the capability of MSFC to secure and retain those types of NRC licenses, which provide the necessary flexibility for operational requirements. This document will include, but will not be limited to, the following subjects:

CH1.4.1.1 Special requirements and procedures for the acquisition, accountability, and control of radioactive material and radiation devices;

CH1.4.1.2 Functions and procedures of the RSC;

CH1.4.1.3 Radiological safety procedures and radiation monitoring; and

CH1.4.1.4 Procedures for securing approval of work involving the use of ionizing radiation, including user requests, licenses from NRC, and special work permits.

CH1.5 User

CH1.5.1 The user or operator of any ionizing radiation source shall have adequate training and experience to receive, use, and have custody of specific regulated sources of ionizing radiation, as determined by the RSC.

CH1.5.2 Authorized radiation users or operators shall be responsible for ensuring compliance with the provisions of this Directive.

CH1.6 Radiation Use Authorizations

CH1.6.1 In order for the RSC to evaluate potential hazards associated with the use of a regulated radiation source, a "Radioactive Material Use Authorization" (MSFC Form 4416) or "Radiation Machine Use Authorization" (MSFC Form 4415) shall be submitted by the proposed user of the radiation source. The requested use authorization shall contain a description of the operating procedures, which include detailed safety precautions, the use locations, emergency procedures, and identifies the qualifications of proposed users and their NASA supervisor or technical monitor. Prior to, or concurrent with the preparation of the radiation use request, the RSO shall perform a radiological safety analysis, or initial radiation protection survey, and a report of these findings shall be submitted to the RSC, along with the radiation use request.

CH1.6.2 The RSC will review the originator's proposal, the user's qualifications, and recommendations made by the RSO. If satisfied that the proper precautions are to be taken, they will approve the request, binding the users to all statements represented. If additional recommendations are considered appropriate by the Committee, a written condition shall be added to the authorization applicable to each recommendation.

CH1.6.3 Modifications to approved authorizations shall be submitted on MSFC Form 4415 or Form 4416 and follow the same processing as the original request. In addition to materials presented by the originator, for consideration by the Committee, previous survey results and hazard evaluations shall be given primary importance for approval of renewed or modified use authorizations. Information contained in previous submittals to the MSFC RSC may be incorporated by reference provided references are clear and specific.

CH1.7 Special Requirements For Off-site Radiation Use Authorization

CH1.7.1 Prior to approving a radiation use authorization for an organizational element of MSFC in which the material or equipment will be used at a temporary job site (a facility not under the administrative control of MSFC), the following requirements shall be satisfied:

CH1.7.1.2 Written authorization shall be obtained from the administration of the facility where use of radioactive materials is proposed. If the facility or institution holds a byproduct license from the NRC or an agreement state, the use of byproduct materials should be concurred on by the local RSO and/or the MSFC RSC.

CH1.7.1.3 To ensure minimal radiation exposure to individuals and confirm no residual radioactive contamination remains in the facility, an individual shall be named with adequate training and experience in radiological health activities to select suitable instrumentation and perform monitoring tasks as determined necessary by the MSFC RSC.

CH1.7.1.4 Procedures and arrangements for disposal, to handle radioactive waste generated at the temporary job site, shall be formally specified and approved by the MSFC RSC. The preferred waste disposal method shall be by direct transfer to NRC or agreement state licensee authorized to perform collection and/or disposal of radioactive waste.

CH1.7.1.5 Duration of radiation use under these procedures shall be limited to 30 days inclusive. When a demonstrated need for a longer use period exists, the request for radiation use authorization shall be submitted at least 60 days in advance of the needed date to allow time for the MSFC RSC to secure the necessary approval from the NRC.

CH1.7.1.6 All records of radiation surveys, personnel monitoring, and radioactive material transfers shall be maintained by the use supervisor and submitted to the RSO at the completion of the authorized use. Any incidents involving individuals overexposed, lost sources, or contamination problems shall be reported immediately to the RSO at MSFC, in accordance with Chapter 4 of this Directive.

CH1.8 Interim Approvals

CH1.8.1 The RSC has established a policy for timely response between meetings to requests for use. Small changes to approved

uses or new uses that involve low risk can be provisionally approved by the written concurrence of the Chairman of the RSC and the RSO.

CH1.8.2 Only with approval of both the Chairman of the RSC and RSO is the interim use authorized, and then only until the next scheduled meeting of the RSC at which time it is reviewed by the full committee.

CH1.8.3 Approval may be withdrawn at any time if safety violations occur or use of a regulated source is found not to be in compliance with conditions of the approved use.

CHAPTER 2

PROCUREMENT OF RADIOACTIVE MATERIALS AND RADIATION-PRODUCING DEVICES

CH2.1 General Procedures

CH2.1.1 Radioactive materials fall into the following four categories with respect to the control exercised by the NRC and the RSC:

CH2.1.1.1 Generally Licensed Material - Material controlled by 10 CFR 31.

CH2.1.1.2 Specifically Licensed Material - All other material controlled by the NRC that cannot be obtained under a general license (refer to 10 CFR 30, 32, and 33).

CH2.1.1.3 Radiography Licenses - Material controlled by 10 CFR 34.

CH2.1.1.4 Material Not Controlled by the NRC - Certain naturally occurring radioisotopes, i.e., radium, radon, etc., and accelerator-produced isotopes.

CH2.1.2 Formal application for a specific license must be submitted to the RSC for any of the above, as outlined in Chapter 1.

CH2.1.3 Procurement requests for all radioactive materials will be routed through the RSO for review and approval prior to processing. The procedure is as follows:

CH2.1.3.1 To obtain byproduct materials, it is necessary to submit NRC Form 313, “Application for Byproduct Material License,” to the NRC. The user will send to the RSO (in letter form) sufficient information for completion of this form (by the RSO) and subsequent submittal to the NRC. The user will prepare appropriate MSFC procurement request documentation and route it through the RSO for review and approval.

CH2.1.3.2 All procurements will cite the following clause for inclusion in all purchase orders and contracts for radioactive materials or service irradiation: “In addition to the labeling required by CFR Title 49, Part 172.403, all outside packaging shall be conspicuously identified as containing radioactive material.”

CH2.1.3.3 The RSO will stamp RADIOACTIVE MATERIAL on the request for procurement to ensure its proper identity to personnel concerned. Such material will be classified as controlled property so that a permanent record of the radioactive material can be maintained.

CH2.1.3.4 After review and approval as outlined in Chapter 1, the RSO will forward the request for procurement to the Property Management Group (PMG) for processing.

CH2.1.3.5 The PMG will supply the RSO with an information file copy of the procurement request.

CH2.1.3.6 The Procurement Office will include the radioactive materials clause in all purchase orders and contracts.

CH2.1.4 The transfer of radioactive materials beyond the control of the individuals authorized or the diversion of such radioactive materials to uses other than those described in the approved application will not be made without the approval of the RSO/RSC.

CH2.2 Radiation-Producing Devices

CH2.2.1 Chapters 7 and 8 of this document outline specific rules governing approval for the use of devices that produce radiation. These chapters should be consulted in detail before any action is taken to begin an operation. After it is decided that such an operation will begin, the procedures listed below must be followed in obtaining approval for purchase.

CH2.2.2 To obtain devices that produce ionizing radiation, it is necessary that approval of the RSO be obtained. The person requesting the device will forward the completed procurement request to the RSO for review.

CH2.2.3 After review, the RSO will make the following disposition of the procurement request:

CH2.2.3.1 If disapproved, it will be returned to the originator with specific requirements for additional information.

CH2.2.3.2 If approved, it will be forwarded to the PMG.

CHAPTER 3

DISPOSAL OF RADIOACTIVE MATERIAL

CH3.1 General

CH3.1.1 The proper methods to follow for the disposal of any item of radioactive material that becomes unserviceable or unnecessary are included in this chapter.

CH3.1.2 Some items may be returned to the supplier for repair or disposition. These procedures are applicable regardless of whether the sources require disposal or return to the manufacturer.

CH3.2 Applicability

This chapter includes procedures for all items of radioactive material, including waste, that require disposal regardless of whether the item is controlled by the NRC.

CH3.3 Procedure

CH3.3.1 For items requiring disposal, an MSFC Form 57, “Shipping Document,” will be forwarded to the RSO. This will transfer the accountability of the property to the RSO. This request will include, as minimum information about the item(s), the following:

CH3.3.1.1 Nomenclature

CH3.3.1.2 Brief description of the item(s)

CH3.3.1.3 Millicuries of activity

CH3.3.1.4 Description of container(s)

CH3.3.2 In cases not covered by this Directive, or where any uncertainty exists, the RSO should be contacted for specific instructions.

CH3.3.3 Upon receipt of MSFC Form 57, the RSO will take the appropriate action to obtain disposition instructions and to dispose of the item(s). The RSO will prepare all shipping documents and makes arrangements for transportation of the item(s) to the disposal/burial site.

CH3.3.4 An MSFC Form 57 shall be sent to the RSO for disposal

of radioactive material. The MSFC RSO is the only source for disposal of radioactive material.

CHAPTER 4

RECEIVING, SHIPPING, AND STORING OF RADIOACTIVE MATERIAL

CH4.1 General

CH4.1.1 The receiving, packaging, shipping, and storing of radioactive material must be coordinated and controlled to keep personnel exposure ALARA. All radioactive material received, transported, stored, or shipped at MSFC shall be appropriately packaged, shielded, and labeled.

CH4.2 Applicable Directives

CH4.2.1 The packaging and labeling of both incoming and outgoing shipments of radioactive material must comply with Department of Transportation (DOT) regulations and/or the International Air Transport Association (IATA).

CH4.2.2 The shipping and receiving of radioactive material will be governed locally by the MSFC RSO.

CH4.3 Responsibilities

CH4.3.1 The authorized user must ensure proper identification, shielding, and containment of all material to be shipped off the Center or to be transported within the Center. All shipping containers must be labeled in accordance with DOT and/or IATA regulations. All onsite and offsite transportation of radioactive material will be coordinated with and approved by the RSO.

CH4.3.2 The Transportation and Logistics Engineering Group is responsible for providing proper outside container and packaging in accordance with DOT and/or IATA regulations. The RSO will provide technical guidance as necessary.

CH4.3.3 The RSO is responsible for inspecting, labeling, and shipping in accordance with DOT, IATA, and/or NRC regulations.

CH4.3.4 The RSO will supply technical information as required.

CH4.4 Incoming Shipments

CH4.4.1 Receipt of incoming shipments will be performed by the Transportation and Logistics Engineering Group.

CH4.4.2 The Transportation and Logistics Engineering Group will immediately notify the RSO of the arrival of a shipment by phone, giving all available information such as type of material, amount, size of package, to whom addressed, etc.

CH4.4.3 The RSO or alternate will immediately proceed to the receiving area and inspect/survey the shipment. After assurance that the shipment is in proper order and that the addressee is authorized to receive the material, the RSO or alternate will authorize the Transportation and Logistics Engineering Group supervisor to take action as appropriate.

CH4.4.4 All incoming shipments of radioactive materials shall be coordinated with the MSFC RSO or alternate to ensure proper licenses are valid.

CH4.4.5 If the RSO or alternate is not available, the shipment will be stored in the hazardous chemical area of receiving until he/she is available.

CH4.5 Outgoing Shipments

CH4.5.1 The authorized user shall notify the RSO prior to any shipment of radioactive material.

CH4.5.2 The user will ensure that the outgoing shipment is adequately shielded, contained, and identified. Packaging of radioactive material will preferably be accomplished by the user in the location where the material is authorized to be used. However, if this is not feasible, the user shall notify the PMG that the user has a radioactive source that requires packaging. The PMG will issue the necessary documents for shipping the material.

CH4.5.3 Packaging and labeling requirements are continued in sections 4.7 and 4.8.

CH4.5.4 The RSO will provide technical advice or assistance as necessary in any phase of the preparation for shipment.

CH4.5.5 The RSO will sign all shipping documents.

CH4.6 Intracenter Transportation

CH4.6.1 Approval by the RSO will be required for movement of radioactive material to a different location.

CH4.6.2 Radioactive material to be transported on the Center will be packaged and shielded so that the radiation level does not exceed 10 millirem/hour at 1 meter from the surface of the package and the radiation level on the surface of the package does not exceed 200 millirem/hour.

CH4.6.3 Standard radiation warning postings required by CFR Title 10, Part 20, shall be used.

CH4.6.4 The driver of the vehicle will be apprised of the nature of his cargo. It is highly desirable that the user accompany the driver.

CH4.6.5 If there is a vehicle accident, the driver shall notify the security guards and the RSO immediately.

CH4.6.6 The security guards will keep all persons away from the accident area until the RSO or alternate has determined that the area is safe.

CH4.7 Packaging

CH4.7.1 In general terms, the following requirements apply to packaging of radioactive material for shipment. If more specific information is needed, the RSO will furnish appropriate information from CFR Title 49, Department of Transportation:

CH4.7.1.1 The radiation source must be sealed in an airtight container such as a polyethylene or plastic bag so that no radioactive material may escape.

CH4.7.1.2 There must be no detectable surface contamination.

CH4.7.1.3 The smallest allowable dimension of the outside container is 4 inches.

CH4.8 Labeling

A label is required for radioactive materials that meet the requirements of CFR Title 49, Parts 172.400, 172.401, 172.402, 172.403, 172.404, 172.406, 172.407, 172.436, 172.438, and 172.440.

Illustrations of labeling are not available electronically.

CHAPTER 5

PERSONNEL EXPOSURE

CH5.1 Reference

CFR Title 10, Part 20, “Standards for Protection Against Radiation”

CH5.2 General

CH5.2.1 Personnel exposure is to be maintained ALARA. Personnel exposure is divided into two categories:

CH5.2.1.1 Internal exposure resulting from radioactive material taken into the body by ingestion, inhalation, and absorption through the skin or through wounds.

CH5.2.1.2 External exposure resulting from the body being exposed to radiation from radioactive materials and ionizing radiation produced by machines.

CH5.2.2 The population is divided into four groups for determining dose limits:

CH5.2.2.1 Occupationally exposed adults; i.e., the small segment of the population whose job requires exposure to ionizing radiation.

CH5.2.2.2 Occupationally exposed minors; i.e., the small segment of the population whose job requires exposure to ionizing radiation. The dose limits for individuals less than 18 years of age is 10% of the applicable dose limit for adults.

CH5.2.2.3 Declared pregnant occupationally exposed women: The total effective dose equivalent to an embryo/fetus during the entire pregnancy will not exceed 0.5 rem (5 mSv), and an effort will be made to avoid substantial variation above a uniform monthly exposure rate.

CH5.2.2.4 General Public; i.e., the large segment of the population who are not included in the previous three categories. The annual total effective dose equivalent limit for these individuals is 0.1 rem (1 mSv).

CH5.2.3 In addition, members of the general public will not

be exposed to external sources in such a manner that they would receive a dose in excess of 2 millirem (0.02 mSv) in any one hour.

CH5.2.4 The area in which radiation dose rates may exist in excess of 2 millirem/hr must be under the control of the user or the supervisor responsible for the facility and access to the area must be restricted.

CH5.2.5 Radiation dose limits as outlined in this section do not include doses received from natural background and medical and dental procedures.

CH5.2.6 Concentrations of effluents in unrestricted areas shall be governed by provisions of 10 CFR 20.

CH5.3 Definitions of Units

See definitions on page 6.

CH5.4 Dose Limits for Occupationally Exposed Adults

CH5.4.1 The provisions of 10 CFR 20 shall be strictly adhered to in determining dose limits and quantifying internal and external doses to individuals.

CH5.4.2 With the exception of doses received resulting from planned special exposures, the following annual limits apply:

CH5.4.2.1 For the whole body, the more restrictive of

a. Total effective dose equivalent of 5 rem (0.05 Sv).

b. The sum of deep dose equivalent and committed dose equivalent to any organ or tissue other than the lens of the eye of 50 rem (0.5 Sv).

CH5.4.2.2 For the skin of the whole body and the extremities

A shallow dose equivalent of 50 rem (0.5 Sv)

CH5.4.2.3 Lens of the eye: An eye dose equivalent of 15 rem (0.15 Sv)

CH5.4.3 In extraordinary circumstances, an individual may be allowed to receive an emergency dose in excess of the ordinary annual limits. This will be accomplished per 10 CFR 20.1206 and require the written approval of either the RSO or the RSC

Chairman. If both are available, both must provide written approval.

CH5.5 Caution Signs, Labels, and Postings

CH5.5.1 Caution signs, labels, warnings, and postings shall be used in accordance with 10 CFR 20.

CH5.5.2 In addition to the above, other warning devices may be used as prescribed and approved by the RSO.

SPECIAL NOTE: All personnel should be advised that no food or drink should be consumed/used/stored in a radiation work area.

CHAPTER 6

PERSONNEL MONITORING

CH6.1 Reference

CFR Title 10, Part 20

CH6.2 General

CH6.2.1 10 CFR 20 requires that appropriate personnel monitoring equipment be applied to:

CH6.2.1.1 Each individual who is likely to receive an external dose in any calendar year in excess of 10 percent of the applicable value specified in 10 CFR 20.

CH6.2.1.2 Minors and declared pregnant women who are likely to receive an external dose in any calendar year in excess of 10 percent of the applicable value specified in 10 CFR 20.

CH6.2.1.3 Each individual prior to entering a high radiation area or a very high radiation area.

CH6.2.2 In addition to these requirements, personnel monitoring will be provided for all individuals who work in posted radiation areas.

CH6.3 Applicability

These requirements apply to all employees of MSFC, its contractors, its consultants, etc.

CH6.4 Definitions

Refer to definitions on page 6.

CH6.5 Responsibilities

The MSFC OMEHS is responsible for providing dosimetry service at MSFC. The project manager of each activity in which there are projects dealing with radioactive materials or equipment capable of producing or accelerating ionizing particles shall enforce these requirements.

CH6.6 Types of Dosimeters

CH6.6.1 The following dosimetry device(s) is in use at this installation:

CH6.6.1.1 TLD badges

CH6.6.1.2 TLD finger rings

CH6.6.2 TLD badges and finger rings are used to obtain a permanent record of the radiation dose to which the individual has been exposed. TLD badges, which are worn clipped to the clothing, record external exposure. TLD finger rings are worn by personnel utilizing devices, such as x-ray diffraction units, where a need for extremity (finger, hand) dosimetry is present. TLD finger rings also record external exposure.

CH6.7 General Precautions

CH6.7.1 Do not tamper with the TLD. OMEHS will exchange the TLD quarterly. All users will receive a quarterly report of their exposure history (TLD readings).

CH6.7.2 Do not expose the TLD to excessive heat or moisture.

CH6.7.3 Do not leave the TLD in a location where it will be exposed to radiation except when worn by the employee.

CH6.7.4 Always wear the TLD when entering a radiation area, high radiation area, or very high radiation area.

CH6.7.5 Do not take the TLD home. When TLD badges/finger rings are not being worn, they should be kept in the designated location for that work area. Exemptions to this policy may be approved by the RSO.

CH6.7.6 Wear only your own TLD.

CH6.7.7 Report any exposure the TLD may not have recorded to the MSFC RSO.

CH6.7.8 Wear the TLD with the beta window facing outward on the front of the body between the waist and neck unless directed otherwise by the RSO. Wear the TLD finger ring with the chip facing the anticipated radiation beam/beam source unless directed otherwise by the RSO.

CH6.8 How to Obtain TLD

CH6.8.1 The responsible supervisor will, prior to using a radiation source, request a TLD for each individual who will be exposed. This request will be in the form of a letter, memorandum, or electronic mail to the RSO.

CH6.8.2 The information required, for persons assigned a TLD badge, is as follows: first name, middle initial, last name, social security number, type radiation used, building number, room number, date of birth, organization, sex (M/F), and supervisor's name.

CH6.8.3 The MSFC OMEHS will review each individual's medical record, conduct preassignment examinations as deemed necessary, and notify the responsible supervisor if an individual assignment is inadvisable.

CH6.8.4 An NRC Form 4 or equivalent will be completed and signed by the individual requesting dosimetry.

CH6.8.5 Dosimetry record requests forms are available from the RSO.

CH6.8.6 The MSFC OMEHS will furnish a TLD for each individual. The TLDs are numbered by means of a code designator system to identify the individual user.

CH6.8.7 All personnel who will be assigned dosimetry instruments shall attend radiation safety training given by the RSO or other qualified personnel. This training shall be attended at least annually by all radiation-monitored personnel.

CH6.8.8 The MSFC OMEHS will deliver the badges to the user.

CH6.8.9 At the end of the monitoring period, the MSFC OMEHS will promptly collect all badges.

CH6.8.10 If an individual has received an overexposure, the MSFC OMEHS will immediately notify the employee's supervisor and the NRC and OSHA within 24 hours following occurrence. The employee will be removed from radiation exposure. Personnel dosimetry and dose assessments will be analyzed and evaluated by the RSO and MSFC OMEHS. The MSFC OMEHS and RSO will monitor the overexposed individual for any biological effects on a daily basis; ensure health and regulatory requirements are satisfied; and determine when the exposed individual can resume duties.

CH6.8.11 U.S. Nuclear Regulatory Commission Form 5, or its equivalent will be included in the records of individuals who are to be assigned to MSFC. The MSFC OMEHS will maintain cumulative

dose records on each employee exposed to radiation and distribute those records, as required by 10 CFR 20.

CH6.9 Determination of Internal Exposure

In vitro and in vivo bioassays will be performed as deemed necessary by the RSO to determine personnel exposure from internally deposited radio nuclides. Other methods may also be used for internal dose determination, as given in 10 CFR 20.

CHAPTER 7

LEAK TESTING SEALED SOURCES

CH7.1 References

10 CFR 34.27, “Leak Testing and Replacement of Sealed Sources”

CH7.2 Definition

“Sealed Source” means radioactive material that is encased in, and is to be used in, a container in a manner intended to prevent leakage of the radioactive material.

CH7.3 Types of Sealed Sources

CH7.3.1 Gamma ray sources such as Co-60, Cs-137, and Ir-192 are used in radiography and other industrial applications and in medical therapy.

CH7.3.2 Beta sources such as Sr-90, Y-91, Tc-99, and Pm-147 are used as density gages, nuclear batteries, static eliminators, etc.

CH7.3.3 Alpha-emitting sources such as Ra-226 and Am-241.

CH7.4 Deterioration or Rupture of Containers

CH7.4.1 Encapsulating material for beta ray sources must be thin and, consequently, it is easily damaged. Leakage of gamma ray sources such as Cs-137 and Co-60 has been found to occur. Any leakage is serious since the escaping material can contaminate surfaces that it contacts and may be inhaled or ingested into the body. Alpha emitters, such as Ra-226 and Am-241 present a serious internal exposure hazard because of the long effective half-life of the nuclides and the high linear ion density of the alpha particles.

CH7.4.2 Several factors may cause the container or its seal to leak or become damaged:

CH7.4.2.1 Radiation from the source itself, either direct or indirect, which accelerates corrosion either directly or by production of corrosive ozone in the air.

CH7.4.2.2 Attack by chemicals inside the source.

CH7.4.2.3 Attack by corrosive fumes, solvents, or other chemicals to which the source may be exposed.

CH7.4.2.4 Buildup of gaseous pressure inside the encapsulating material by the action of radiation or by heating, such as might occur during a fire.

CH7.4.2.5 Breakdown resulting from the discharge of high electrical potentials accumulates by the transmission of beta particles through insulating material.

CH7.4.2.6 Vibration, shock, or other mechanical injury.

CH7.4.2.7 Stresses set up by differences in thermal expansion.

CH7.4.2.8 Deterioration inherent in the materials used for the container, e.g., loss of solvents or plasticizers from plastics.

CH7.4.2.9 Damage from high or low temperatures, humidity, low pressure experienced in shipment by air, or any other unfavorable environmental conditions that might occur.

CH7.5 Detecting Leaks

For the foregoing reasons, it is mandatory that leak tests be performed on all sealed sources upon receipt and at intervals as specified by NRC. The conditions detailed in NRC licenses concerning possession and use of sealed radioactive sources include requirements for performing leak tests and maintaining records of the results.

CH7.6 Equipment Required for Performing Leak Tests

CH7.6.1 Long-handled forceps or tongs for handling sources

CH7.6.2 A Geiger-Mueller survey meter

CH7.6.3 Filter paper, cotton, and cotton swabs attached to sticks for wiping the container and envelopes

CH7.6.4 A sensitive counter capable of measuring a removable contamination of 0.005 microcuries (185 Bq)

CH7.6.5 Protective gloves

CH7.6.6 TLD badge(s)

CH7.6.7 Appropriate shielding

CH7.7 Procedure

CH7.7.1 Storage containers enclosing sealed sources will be opened in a restricted area to which entry is controlled by the user.

CH7.7.2 Personnel performing the leak tests will wear TLD badges.

CH7.7.3 The individual making the test will follow the procedures listed below:

CH7.7.3.1 Use protective gloves and accessories.

CH7.7.3.2 Cautiously remove the cover of the storage container so as not to spread contamination in the event the source should be leaking.

CH7.7.3.3 Do not expose the body to a direct beam from the container, if possible.

CH7.7.3.4 Gently wipe the recess in the storage container with a cotton swab on a stick or with filter paper held in long-handled tongs. Remove the wipe and Geiger-Mueller survey meter from the radiation field to a location where only background is indicated on the meter. Switch the meter to its lowest range and survey the wipe.

CH7.7.3.5 If no reading above background is obtained, remove the source from the storage container with the tongs or a handling device. Use shielding between the source and the body. Wipe the surface of the sealed source with a cotton swab attached to a stick. Return the source to the storage container and replace the cover.

CH7.7.3.6 Again survey the wipe with the Geiger-Mueller survey meter on the lowest scale away from the radiation field. If the reading does not exceed background, place the swab in an envelope with the source number and date listed on it.

CH7.7.3.7 Take the test swabs to the testing location where they will be checked by the counter described in CH7.6.4.

CH7.7.3.8 Convert the counts/minute obtained into microcuries of removable contamination and record.

CH7.7.3.9 Other techniques may be approved by the RSO/RSC.

CH7.8 Radiography and Similar Sealed Sources

High-intensity gamma ray sources used for radiography or other similar industrial purposes will be leak-tested by wiping the nearest accessible point to the sealed source storage position, and then following the pertinent portions of the procedure outlined in CH7.7.

CH7.9 Leaking Sources

CH7.9.1 In the event the removable contamination exceeds 0.005 microcuries (185 Bq), the source is considered to be leaking. The source container will be closed and tagged until it can be prepared for shipment.

CH7.9.2 Sources that are leaking may be repaired by licensed manufacturers if it is economically feasible; if not economically feasible, they may be disposed of as outlined in Chapter 3.

CHAPTER 8

EMERGENCY PROCEDURES FOR CONTROL OF RADIOACTIVE CONTAMINATION

CH8.1 References

CH8.1.1 United States Public Health Service (USPHS) “Radiological Health Handbook”

CH8.1.2 National Bureau of Standards Handbook 48, "Control and Removal of Radioactive Contamination in Laboratories"

CH8.1.3 MWI 8621,1, “Close Call and Mishap Reporting and Investigation Program”

CH8.2 General

CH8.2.1 Radioactive contamination is easily spread during an emergency situation such as a fire, explosion, accidental breakage of a container, or spilling. Radioactive materials can be spread very rapidly and easily by the air currents set up by a fire. They may also find their way into an air conditioning system, or if spilled on the floor, may be tracked around by personnel. This contamination is undetectable except by the use of special radiation-detecting devices. Since it is extremely difficult to set up adequate detection controls in an emergency, this chapter has been prepared to present preplanned emergency procedures. Personnel whose work involves the use of radioactive materials shall familiarize themselves with these procedures.

CH8.2.2 Because of the potential for personnel injury, all incidents involving unplanned release or contamination should be treated as mishaps and the responsible supervisor shall follow MWI 8621,1, “Close Call and Mishap Reporting and Investigation Program.”

CH8.3 Emergency with No Associated Injury to Personnel

CH8.3.1 Immediately after the occurrence of a spill, breakage of a container, or any accident resulting in the release of radioactive material, the involved person must accomplish the following:

CH8.3.1.1 Notify all other personnel to vacate the room, and prevent them from approaching the contaminated area or from attempting to deal with the spillage.

CH8.3.1.2 Notify the RSO by telephone, or by the most rapid method of communication, and follow his/her instructions or those of his/her authorized representative. Unless otherwise instructed in advance, close all windows and other openings such as ventilating grills and shut off air condition systems, electric fans, etc.

CH8.3.1.3 Close all doors.

CH8.3.1.4 If the spillage involves powder or gaseous radioactive material, seal all doors and other openings. Suitable materials for sealing are wide masking tape or heavy wrapping paper, which may be clipped or pasted to the frames.

CH8.3.1.5 Survey all personnel suspected of being contaminated.

CH8.3.1.6 Initiate decontamination procedures immediately for any personnel contaminated.

CH8.3.1.7 Ensure that no one (excluding fire fighters) enters the evacuated areas unless they are equipped with protective equipment.

CH8.3.2 After a spill, all personnel in the general area are affected by the rules listed below:

CH8.3.2.1 No person shall enter the area until the RSO has conducted radiological surveys and has pronounced the area safe for resumption of work.

CH8.3.2.2 Unauthorized personnel shall not attempt to make a survey or to clean up the spillage. Under special circumstances, properly authorized personnel shall direct and closely supervise these tasks.

CH8.3.2.3 Decontamination procedures shall always be conducted under the supervision of the RSO or his/her authorized representative.

CH8.3.2.4 Personnel shall keep their movements in the contaminated area to a minimum to avoid spreading the contaminant by tracking.

CH8.4 Emergency with Associated Injury to Personnel

CH8.4.1 In the event of an emergency with associated injury to personnel, the following procedures apply:

CH8.4.1.1 All injured persons who may be contaminated with radioactive material and who require more than on-the-spot first aid will be taken from the scene to an appropriate emergency medical care facility. Transportation will be by ambulance only.

CH8.4.1.2 Emergency medical services may be summoned by calling 911; the dispatcher shall be told that the injured person may be contaminated with radioactive material.

CH8.4.1.3 The RSO and OMEHS will work together to decontaminate and treat all patients that can be adequately treated at the scene.

CH8.4.1.4 Emergency medical personnel will determine whether the patient has a concomitant serious medical condition or injury that cannot be adequately treated at this location.

CH8.4.1.5 If there is a serious medical condition or injury that cannot be adequately treated at the location, emergency medical personnel or the RSO will so inform other responding emergency services and Huntsville Hospital so that the procedure for handling radioactively contaminated patients can be instituted.

CH8.4.1.6 All preliminary decontamination of the patient will be accomplished as time and conditions permit. (Removal of clothes may remove most of the contamination from the patient.)

CH8.4.1.7 The RSO will notify emergency medical personnel and the hospital of the probable amount and type of contamination of patients being forwarded and of any special precautions that should be taken.

CH8.4.1.8 The RSO (if available and if prudent) will survey the exterior of the ambulance for contamination before allowing it to leave the scene to deliver the patient. The critical needs of the patient take priority over contamination control.

CH8.4.1.9 All equipment or material used on the patient or at the scene will be considered as contaminated until it is checked by the RSO or his/her representative and cleared or decontaminated as necessary.

CH8.4.1.10 The responding emergency medical services will remain at the delivery site until the RSO or his/her representative surveys the ambulance for contamination. The RSO will direct any necessary decontamination.

CH8.5 Decontamination Procedures

Contamination of personnel, plant areas, or equipment areas may present emergency conditions following an accident. Prompt measures must be taken to identify contaminated personnel and to perform required decontamination. Under only life or property saving emergency conditions will a person contaminated with radioactive material leave the area until released by the RSO or his/her representative. Subsequently, and as soon after a survey of contamination as possible, preplanned decontamination methods shall be applied to the contaminated plant areas and equipment. Only the RSO or his/her authorized delegates shall decontaminate or supervise the decontamination of personnel or material.

CH8.6 Procedure for Decontaminating Personnel

CH8.6.1 All contaminated clothing or clothing suspected to be contaminated shall be removed and placed in suitable waste containers (a plastic bag within a plastic can or equivalent) for later disposal.

CH8.6.2 If the skin is affected, the contaminated area shall be scrubbed thoroughly for 2 to 3 minutes, soaping and rinsing repeatedly. Consideration shall be given to the chemistry of the contaminant, and an attempt shall be made to find a suitable agent for dissolving it. Any cleansing agent may be used, but synthetic detergents are preferred to soap. (Note: Prolonged decontamination may result in irritation of the skin and should be avoided.)

CH8.6.3 In serious cases, a physician and emergency medical services shall be called immediately, but the decontamination shall proceed until further instructions are provided. If internal contamination is suspected, the physician and emergency medical service personnel must be notified so that appropriate biological samples are collected, as required.

CH8.6.4 Personnel engaged in contamination surveys and decontamination operations shall wear appropriate personal protective equipment such as gloves, respirators, coveralls, and shoe covers, as necessary.

CH8.7 Decontamination of Tools and Materials

Under the direction of the RSO, vacuum cleaners, mops, detergents, and wetting agents should be employed on the contaminant. Care must be exercised to prevent these objects from becoming contaminated. Should these objects become contaminated they shall be treated as radioactive waste. Vacuum cleaners shall have high efficiency filtered exhausts.

CHAPTER 9

INDUSTRIAL RADIOGRAPHY X-RAY REGULATIONS

CH9.1 General

CH9.1.1 X-rays are generally of extremely short wavelength and occupy the portion of the electromagnetic spectrum above the ultraviolet region. They may be produced by standard x-ray tubes or particle accelerators. Gamma rays have characteristics identical to x-rays, but they originate in the nucleus. For the remainder of this chapter, the terms x-ray and gamma ray shall be used synonymously, and all requirements will pertain to gamma and x-ray radiography.

CH9.1.2 X-rays and gamma rays are attenuated or absorbed in matter by processes that are dependent on their energy and the mass number of the absorber.

CH9.1.3 All outside radiographers using radioactive materials or x-ray sources must report to the MSFC RSO, Building 4249, Room 116, prior to performing any work at MSFC. At that time, all "paperwork" and required materials including license, equipment, instrumentation, standard operating procedures, and emergency procedures will be checked and if any is not in proper order, the radiographer will be denied access to perform work at MSFC.

CH9.1.4 Involved personnel should review MWI 8715.6, "Hazardous Operations," as it outlines the requirements for hazardous operations; the following are some highlights of the instruction:

CH9.1.4.1 Organizations that perform hazardous operations will maintain a list of all hazardous operations and provide a copy to S&MA.

CH9.1.4.2 Responsible hazardous operations personnel and program/project managers assisted by S&MA identify safety requirements for a hazardous operation for each stage of study, design, construction, and test.

CH9.1.4.3 Hazard assessments shall be performed for all hazardous operations in accordance with MWI 8715.7, "Facility Safety Program." The assessment is conducted in coordination with the responsible hazardous operation authority or technician, program/project manager, facility user, and S&MA.

CH9.1.4.4 MWI 8715.8, "Operational Readiness Program," provides guidelines to assist managers in determining if an operational

readiness review is required. The program manager determines the level of readiness review, with assistance from S&MA, who makes an initial safety assessment.

CH9.1.4.5 NASA-STD-8719.7, “Facility System Safety Guidebook,” provides guidelines for determining the level of readiness review.

CH9.1.4.6 The responsible authority and program/project manager for hazardous test operations will conduct a Test Readiness Review.

CH9.1.4.7 The responsible organization for the facility will maintain configuration control for hazardous facilities.

CH9.2 Purpose

The regulations in this chapter establish radiation safety requirements for MSFC and contractor personnel who utilize any source of x-radiation for industrial radiography.

CH9.3 Definitions

CH9.3.1 As used in this chapter:

CH9.3.1.1 “Radiographer” means any individual who performs or who, in attendance at the site where sources of x-radiation are being used, personally supervises industrial radiographic operations and who is responsible for ensuring compliance with the requirements of these regulations and all license conditions.

CH9.3.1.2 “Radiographer's assistant” means any individual who, under the personal supervision of a radiographer, uses sources of x-radiation, related handling tools, or survey instruments in industrial radiography.

CH9.3.1.3 “Industrial radiography” means the examination of the structure of materials by nondestructive methods utilizing sources of radiation.

CH9.3.1.4 “Person” means any individual who personally utilizes or manipulates a source of radiation.

CH9.4 Protection

The principal method of protection from x-rays is by shielding the tube and by enclosing the machine in a protective housing, a high-density concrete and/or lead-lined room. Other methods used in conjunction with shielding are: restricting the direction of the useful beam, limiting the workload, restricting the occupancy

of adjacent areas, and using interlocks to shut off the beam when the doors or access covers are opened.

CH9.5 New Installations

CH9.5.1 The design criteria and drawings of each new x-ray installation will be submitted to the RSO/RSC for review. Each installation will be designed to limit exposures to those outlined in Chapter 5.

CH9.5.2 After the installation is completed, the RSO will be notified so that a survey with radiation detection instruments can be made before operations begin to ensure adequate protection to operators and personnel occupying adjacent areas.

CH9.6 Existing Installations

CH9.6.1 All entrances into a radiographic cell or other high radiation area shall be provided with interlocks.

CH9.6.2 Only a switch on the radiography control panel shall be used to turn the x-ray generator on and off. The safety interlock system shall not be used to turn off the x-ray generator, except in an emergency. If the interlock system does turn off the x-ray generator, it will not be possible to resume operation without resetting the system.

CH9.6.3 A scram button or other emergency cutoff switch shall be located and easily identifiable in all high radiation areas. Such a cutoff switch shall include a manual reset so that the generator cannot be restarted from the control panel without resetting the cutoff switch.

CH9.6.4 Electrical circuit diagrams of the generator and the associated interlock systems shall be kept current and on file at each facility.

CH9.6.5 All entrances to high radiation areas shall be equipped with easily observable flashing or rotating red or magenta warning lights that operate automatically when, and only when, radiation is being produced. Lights of a different color shall be used when other visual indicators are required.

CH9.6.6 All safety and warning devices, including interlocks, shall be checked at intervals not to exceed 1 month to ensure that they are functioning properly and are appropriately serviced. Permanent records shall be kept for a minimum of 3 years and exact requirements will be provided in each facility OWI.

CH9.6.7 Appropriate, portable radiation monitoring equipment, properly maintained and calibrated, shall be available at the radiographic facility and shall be sensitive to those radiations being monitored.

CH9.6.8 An appropriate radiation monitor shall be used within a radiography control room. This should be an area monitor with an easily observable indicator that warns of radiation levels above a predetermined limit. In addition, wherever possible, a personal alarming rate dosimeter should be worn by personnel entering the cell and/or a portable survey instrument carried into the cell. Additional measures will be implemented to ensure that no inadvertent or unauthorized access is gained to very high radiation areas.

CH9.6.9 Personal radiation dosimeters that measure the expected radiations and that are of sufficient range to be useful under normal and accidental conditions shall be worn by all designated persons.

CH9.6.10 Before a new installation is placed in routine operation, a radiation protection survey shall be made by a qualified expert.

CH9.6.11 A radiation protection survey shall be made each quarter and after any maintenance or alteration has been performed on a unit, source, shielding, and/or office locations of adjacent areas.

CH9.6.12 Records of all radiation protection surveys, inspections, and maintenance performed on the x-ray generator and related components shall be kept current and on file at each facility and shall be periodically reviewed by the radiation protection supervisor.

CH9.7 Organizational Work Instructions (OWI)

CH9.7.1 An adequate OWI is required for the operation of all equipment producing x-rays.

CH9.7.2 The OWI shall be submitted to the RSO/RSC for review and approval prior to commencing operations. It shall include instructions for at least the following:

CH9.7.2.1 The handling and use of sources of x-radiation to be employed such that no person is likely to be exposed to radiation doses in excess of the limits established in 10 CFR 20, “Standards for Protection Against Radiation.”

CH9.7.2.2 Methods and occasions for conducting radiation surveys.

CH9.7.2.3 Methods for controlling access to radiographic areas.

CH9.7.2.4 Methods and occasions for locking and securing sources of radiation.

CH9.7.2.5 Personnel monitoring and the use of personnel monitoring equipment.

CH9.7.2.6 Procedures for testing interlocks and other safety systems at regular intervals.

CH9.7.2.7 The procedures for notifying proper persons in the event of an accident.

CH9.7.2.8 The maintenance of records.

CH9.8 General Radiation Safety Requirements

CH9.8.1 Radiation-producing machines shall be operated only by trained and qualified personnel.

CH9.8.2 Each user shall maintain current logs, which shall be kept available for inspection by the RSO, showing for each source of radiation the following information:

CH9.8.2.1 A description (or make and model number) of each source of x-radiation.

CH9.8.2.2 The identity of the radiographer to whom assigned.

CH9.8.2.3 The location and dates of use.

CH9.8.2.4 A record of interlock and other safety system checks as appropriate.

This paragraph applies only to portable x-ray sources.

CH9.8.3 No user shall permit any person to act as a radiographer or as a radiographer’s assistant unless, at all times during radiographic operations, each person wears a TLD badge. A TLD badge shall be assigned to and worn by only one person.

CH9.8.4 Notwithstanding any provisions in other applicable NRC regulations, areas in which radiography is being performed shall be conspicuously posted as required by 10 CFR 20.

CH9.8.5 During each radiographic operation, the radiographer or radiographer's assistant shall maintain a direct surveillance of the operation to protect against unauthorized entry into a high radiation area, or very high radiation area, as defined in 10 CFR 20 of NRC regulations, except where the area is equipped with a control device or an alarm system, or where the area is locked to protect against unauthorized or accidental entry as described in 10 CFR 20.

CH9.8.6 No radiographic operation shall be conducted unless calibrated and operable radiation survey instrumentation is available and in use at each site where radiographic exposures are made. Radiation survey instrumentation considered portable shall be calibrated at least SEMI-ANNUALLY and nonportable survey instrumentation shall be calibrated at least ANNUALLY.

CH9.8.7 All permanent radiographic installations shall incorporate the use of area radiation monitors. Area radiation monitors shall be calibrated at least annually. If area radiation monitors are not feasible to use at these installations, personnel potentially exposed to x-ray radiation from these units shall wear alarming rate dosimeters. Alarming rate dosimeters shall be calibrated at least annually.

CH9.8.8 All alarming rate dosimeters shall have their alarming levels set as: 10 mrem/hour - dose rate; 10 mrem - dose accumulated.

CH9.8.9 The user shall maintain sufficient calibrated and operable radiation survey instruments to make physical radiation surveys. Each radiation survey instrument shall be calibrated at intervals not to exceed 6 months, and, after each instrument servicing, a record shall be maintained of the latest date of calibration. Instrumentation required by this chapter shall have a range such that 2 millirem/hour through 2 Rem/hour can be measured.

CH9.8.10 Each source of x-radiation shall be provided with a lock or outer-locked container designed to prevent unauthorized or accidental production of radiation, and the controls shall be kept locked at all times except when under direct surveillance.

CH9.8.11 Full use of engineering controls will be made. The RSO shall be notified in cases where engineering controls have failed.

CH9.8.12 Any restrictions on the use of the machines recommended by the RSO will be observed.

CH9.9 Limitations

CH9.9.1 The user shall not permit any person to act as a radiographer until such person:

CH9.9.1.1 Has been instructed in the subjects outlined in CH9.10 and has demonstrated an understanding of them.

CH9.9.1.2 Has received a copy of this document and the users operating and emergency procedures and has demonstrated an understanding of them.

CH9.9.1.3 Has demonstrated competence in the use of exposure devices, related handling tools, and survey instruments that will be employed in his assignment.

CH9.9.2 The user shall not permit any person to act as a radiographer's assistant until such person:

CH9.9.2.1 Has received copies of the instructions in the user's operating and emergency procedures and has demonstrated an understanding of them and has demonstrated competence to use, under the personal supervision of the radiographer, the radiographic exposure devices, related handling tools, and radiation survey instruments that will be employed in his assignment.

CH9.10 Radiation Training Outline

CH9.10.1 Radiation handlers, operators, etc., must be certified per MWI 3410.1, "Personnel Certification Program"(complete a MSFC Form 4083 and 4083-2).

CH9.10.2 Radiation handlers, operators, etc., must be trained in fundamentals of radiation safety which should cover, as a minimum:

CH9.10.2.1 Characteristics of gamma and x-radiation

CH9.10.2.2 Units of radiation dose (rem, sievert) and quantity of radioactivity (curie, bequerel)

CH9.10.2.3 Hazards of excessive exposure to radiation

CH9.10.2.4 Levels of radiation from sources or machines

CH9.10.2.5 Methods of controlling radiation dose:

a. Working time

b. Working distance

c. Shielding

CH9.10.3 Radiation detection instrumentation to be used

CH9.10.3.1 Use of radiation survey instruments:

a. Operation

b. Calibration

c. Limitations

CH9.10.3.2 Survey techniques

CH9.10.3.3 Use of personnel monitoring equipment

TLD badges/finger rings

CH9.10.4 Radiographic equipment to be used

CH9.10.4.1 Remote handling equipment

CH9.10.4.2 Radiographic exposure devices

CH9.10.4.3 Storage containers

CH9.10.5 The requirements of pertinent federal regulations

CH9.10.6 The user’s written operating and emergency procedures

CHAPTER 10

ANALYTICAL X-RAY DEVICES

CH10.1 General

Although there are published reports dealing with radiation protection and apparatus design, there is a lack of generally accepted standards or recommendations for x-ray diffraction and spectrographic equipment. For these reasons, the RSO, using material developed by the Medical and Occupational Radiation Program of the National Center for Radiological Health, has formulated the contents of this chapter. Those statements containing the word “shall” are considered necessary to meet minimal standards for protection; those statements using the word “should” are considered advisory and are to be applied when practical.

CH10.2 Responsibilities

CH10.2.1 For each operation using radiation-producing devices, a person shall be appointed to be responsible for radiation safety. This person should be familiar with the basic principles of radiation protection and the particular hazards of the specific device under consideration. This person shall be responsible for the following:

CH10.2.1.1 Ensuring that operational procedures pertaining to radiation safety are established and carried out so that the radiation exposure of each worker is kept at a minimum.

CH10.2.1.2 Providing instruction in safety practices for all personnel who work with or near the equipment.

CH10.2.1.3 Arranging for the establishment of radiation control areas, including placement of appropriate radiation warning signs and/or devices.

CH10.2.1.4 Arranging for periodic regular testing of safety features such as interlocks, warning lights, etc., and for permanent record keeping.

CH10.2.1.5 Providing periodic radiation safety inspection of the equipment and operations.

CH10.2.1.6 Reviewing modifications to x-ray apparatus, including x-ray tube housing, cameras, diffract meters, shielding, and safety interlocks.

CH10.2.1.7 Investigating any case of abnormal radiation exposure of personnel.

CH10.2.1.8 Closely coordinating all of the above with the RSO/RSC.

CH10.2.2 Operating officials will further ensure that:

CH10.2.2.1 Individuals who act as operators of analytical x-ray devices receive an acceptable amount of training in radiation safety (refer to Chapter 12 of this document).

CH10.2.2.2 Operators have demonstrated competence in the use of x-ray devices and radiation survey equipment.

CH10.2.2.3 Operators' radiation exposure records as derived from personnel-monitoring devices are kept at the OMEHS.

CH10.2.3 The operators of analytical x-ray equipment shall be responsible for all operations associated with the equipment, including radiation safety. In particular, he/she shall:

CH10.2.3.1 Keep radiation exposure to self and to others at a minimum.

CH10.2.3.2 Be familiar with safety procedures as they apply to each machine.

CH10.2.3.3 Wear personnel-monitoring devices.

CH10.2.3.4 Notify his/her supervisor and the RSO/RSC of known or suspected abnormal radiation exposures to self or others.

CH10.3 Operating Procedures

CH10.3.1 For each operation involving analytical x-ray devices, operating procedures reflecting safety practices will be prepared. As a minimum, the following points must be covered. Other points applicable to the specific equipment shall also be included.

CH10.3.1.1 Personnel shall not expose any part of their body to the primary radiation beam.

CH10.3.1.2 Only trained personnel (assure requirements of MWI 8715.2, “Lockout/Tag out Program,” are met) shall be permitted to install, repair, or make other than routine modifications to the x-ray generating apparatus and the tube housing apparatus complex.

CH10.3.1.3 Procedures and apparatus utilized in beam alignment should be designed to minimize radiation exposure to the operator.

CH10.3.1.4 Written emergency procedures pertaining to radiation safety shall be established and shall be posted in a conspicuous location.

CH10.3.1.5 If, for any reason, it is necessary to alter safety devices temporarily, such as by removing shielding or bypassing interlocks, such action shall be specified in writing, approved by the RSO, and posted near the x-ray tube housing so that other persons will know the existing status of the machine.

CH10.3.1.6 Radiation exposure to individuals, either within the radiation controlled area or its surroundings, shall be controlled so that dose limits specified in 10 CFR 20 are not exceeded.

CH10.3.1.7 Personnel monitoring devices will be worn by all personnel.

CH10.4 Area Monitoring

CH10.4.1 Area radiation protection surveys will be made at frequent intervals to detect stray radiation. Records of these surveys will be maintained by the operator.

CH10.4.2 During changes in operations, surveys will be performed for proper placement of shielding or for the location of barriers that limit the entry of persons into the area.

CH10.4.3 In addition to the above, area monitoring locations may be established by the RSO using thermo luminescent dosimeters.

CH10.5 Radiation Protection Engineering Considerations

CH10.5.1 The following considerations apply to the design and construction of all analytical x-ray equipment. Any deviation from these standards must be received and approved by the RSO/RSC.

CH10.5.1.1 The tube housing leakage radiation, measured at a distance of 5 centimeters from the surface of the tube housing with beam ports blocked, shall not exceed 25 millirem (250 μSv) in 1 hour and should not exceed 0.5 millirem (5 μSv) in 1 hour at every specific tube rating.

CH10.5.1.2 Radiation originating within the high-voltage power supply, i.e., transformer and rectifiers, shall not exceed 0.5 millirem (5 μSv) in 1 hour at every specific rating at a distance of 5 centimeters from the housing of the power supply.

CH10.5.1.3 For x-ray diffraction and spectrographic equipment in which the primary x-ray beam is completely enclosed, the stray radiation at a distance of 30 centimeters from the tube housing apparatus complex as measured with a monitor appropriate for the energy range monitored, should be reduced to a minimal level and shall be less than 2 millirem (20 μSv) in 1 hour at every specified tube rating.

CH10.5.1.4 For all analytical x-ray devices the following precautions apply:

a. A warning light shall be provided that turns on automatically when the x-ray tube and/or machine are activated. It shall be visible from all directions.

b. The operator should be in immediate attendance at all times when the equipment is in operation. If this is not possible, for example in extended periods of continuous operation, then access to the equipment should be prevented for those other than the user.

c. When not in operation, the equipment shall be secured in such a way as to be accessible to, or operable by, authorized personnel only. Because the exposure rate at the beam port may be greater than 100,000 roentgens/minute, extreme cautions are necessary to prevent accidental exposure to the primary beam. For this reason, open beam techniques should be used only after all other possibilities have been exhausted.

CH10.5.1.5 Each tube housing apparatus complex should be so arranged as to prevent the entry of parts of the body into the primary radiation beam path or to cause the primary radiation beam to be shut off upon entry into its path.

CH10.5.1.6 A shutter status (open or closed) indicator should be provided on or adjacent to the tube housing, which will automatically indicate the position of each shutter in a readily discernible manner.

CH10.5.1.7 A sign or label bearing the words CAUTION - RADIATION - THIS EQUIPMENT PRODUCES X-RADIATION WHEN ENERGIZED - TO BE OPERATED ONLY BY QUALIFIED PERSONNEL or words having similar intent, shall be placed near any switch that energizes an x-ray tube. The sign or label shall use the conventional radiation caution colors (magenta on a yellow background) and shall bear the conventional radiation symbol.

CH10.5.1.8 A sign or label bearing the words CAUTION - HIGH INTENSITY X-RAY BEAM or words having similar intent, shall be placed on or adjacent to each x-ray tube housing. It should be located so as to be clearly visible to any person who may be working in proximity to the primary radiation beam.

CH10.5.1.9 A red or magenta warning light with the notation “X-Ray On,” or equivalent, shall be located on the control panel and shall light only when the x-ray tube is activated. Also, a labeled x-ray tube status (on or off) indicator, preferably a red or magenta light, should be provided on or near each tube housing so that the tube status is readily discernible.

CH10.5.1.10 Machines that utilize an x-ray diffraction camera should have appropriate ports of the x-ray tube housing arranged so that either:

a. The x-ray tube can be energized only when the camera collimating system is in place, or

b. A shutter mechanism allows the primary radiation beam to pass only when the camera collimating system is in place.

CH10.5.1.11 The coupling between the x-ray tube and the collimator of the diffract meter, camera, or other accessory shall prevent stray x-rays from escaping the coupling.

CH10.5.1.12 Safety interlocks shall not be used to deactivate the x-ray beam, except in an emergency or during testing of the interlock system. If the interlock system does turn off the x-ray beam, it shall not be possible to resume operation without resetting the beam "ON" switch at the control panel.

CH10.5.1.13 All safety devices (interlocks, shutters, warning lights, etc.) shall be tested prior to use and periodically to ensure their proper operation. These tests should be conducted at least once per month (follow specific OWI for appropriate facility). Reports of such tests should be maintained for a minimum of 3 years. However, if a unit is used only rarely, the

safety devices should be checked prior to use and their status recorded.

CH10.5.1.14 All tube head ports that are not used shall be secured in the closed position in a manner that will prevent casual opening. Port covers shall offer the same degree of protection as is required of the tube housing.

CH10.5.1.15 Permanent shielding should be used in preference to temporary shielding. Lead foil should be used carefully, as it is easily distorted and may permit radiation leaks.

CH10.5.1.16 X-ray diffraction and spectrographic equipment should be placed in a room separate from other work area whenever possible.

CH10.5.1.17 Research projects may involve frequent modifications of the analytical x-ray equipment, and there is often an assorted increase in potential radiation hazards. Special efforts are necessary to control the hazards from such machines:

a. Radiation protection surveys should be made routinely and shall be made after each modification of apparatus.

b. Equipment operators shall wear a TLD badge as a radiation-monitoring device.

CHAPTER 11

PARTICLE ACCELERATORS

CH11.1 The Accelerator Safety Program

CH11.1.1 No accelerator facility should operate without an adequate safety program. However, one plan for safety organization will not fit all types of accelerator facilities.

CH11.1.2 The safety program should be designed to protect personnel from injury and equipment from damage. It should: (a) maintain safe working conditions; (b) enable the facility to meet its statutory and legal obligations, such as Federal, State, and local (MSFC) requirements regarding safe conditions, workmen's compensation matters, and liabilities related to injuries; (c) establish procedures and organizations to deal with emergencies, such as fires, explosions, and radiation accidents; (d) conduct necessary inspections; and (e) instruct personnel in safe attitudes and practices.

CH11.1.3 The establishment and support of an effective safety program is ultimately the responsibility of the supervisor of the accelerator operations. He/she should clearly establish the areas and levels of authority for the actual conduct of the program, because everyone in the facility must contribute to it if it is to be completely successful. Furthermore, the supervisor must supply the staff their definition of the status of safety because the staff is occupied with the more interesting objectives of research results and publication.

CH11.1.4 All personnel should be informed through appropriate safety training of the hazards and recommended safe practices related to their work. Each individual should take the initiative in recognizing the hazards that he/she encounters and in taking the proper precautions. Preventive measures by the safety organization throughout the installation are a necessity if individuals are to be fully protected.

CH11.1.5 Any safety program has to strike a balance between minimizing risks and maximizing the use of the facility. At the same time, a proper safety program should cause negligible interference with the work of the facility. When this small interference and expense is compared with the cost of possible accidents, no one should object to a properly planned and administered safety program. The establishment and rigorous

support of operating and radiation safety procedures in accelerator organization and maintenance is of utmost importance.

CH11.1.6 The accelerator safety program should assure:

CH11.1.6.1 That an adequate organization is established to formulate, give advice for, and implement safety policy, beginning at the time the facility is first proposed.

CH11.1.6.2 That buildings and facilities provide an environment for safe conduct of experiments or production, and limit the extent of damage caused by an equipment malfunction.

CH11.1.6.3 That safety is integrated into a project from its beginning and that the project is periodically reviewed by responsible persons to ensure that continuing consideration is being given to problems of safety.

CH11.1.6.4 That there is an identification and evaluation of hazards at all stages of an experiment or irradiation process--from conception through operation and deactivation.

CH11.1.6.5 That there exists multiple and, where possible, sequential safeguards to provide defense in depth in the event of equipment failure and/or human error.

CH11.2 Organization for Safety

CH11.2.1 Organization for safety in an accelerator installation should provide for radiation safety, accelerator safety, and general safety. The Radiation Protection Coordinator (RPC) (see CH11.3) should review proposed experiments and facility changes or deviations from standard operating procedures. The safety committee should also compile and publish rules and procedures for safe practices in their facility. The safety committee should perform the following:

CH11.2.1.1 Formulate safety policy.

CH11.2.1.2 Establish review procedures and identify hazards.

CH11.2.1.3 Coordinate and review safety activities.

CH11.2.1.4 Examine requests for variances.

CH11.2.1.5 Advise the director, staff, and user groups on safety matters.

CH11.2.2 Responsibilities for radiation safety should include:

CH11.2.2.1 Inventory and control of radioactive sources, targets, and other activated materials.

CH11.2.2.2 Observation and control of radiation hazards.

CH11.2.2.3 Radioactive waste storage and disposal.

CH11.2.2.4 General radiation monitoring procedures.

CH11.2.2.5 Instruction of personnel in the observation of rules and monitoring procedures.

CH11.2.2.6 Maintenance of records related to exposures and accumulated doses received by the personnel.

CH11.2.2.7 Periodic, routine survey of the accelerator installation.

CH11.2.2.8 Periodic testing of interlocks and other safety systems.

CH11.2.2.9 Surveys of new experimental setups.

CH11.2.2.10 Survey of unusual conditions including conditions during maintenance operations.

CH11.2.3 The person in charge of accelerator safety should have adequate experience related to the accelerator. He/she should be responsible for the mechanical and electrical safety related to:

CH11.2.3.1 Target systems

CH11.2.3.2 Beam transport systems

CH11.2.3.3 Auxiliary mechanical equipment

CH11.2.3.4 Special fire protection

CH11.2.3.5 Control systems

CH11.2.4 In addition, he/she should be responsible for the instruction of accelerator operators and technicians, keep the operators adequately informed of the radiation fields, and disseminate information about safety procedures and special hazards.

CH11.2.5 Responsibilities for general safety procedures are addressed in MPG 8715.1, "Marshall Safety, Health, and Environmental (SHE) Program." At a minimum they should include:

CH11.2.5.1 Storage and safe use of chemicals

CH11.2.5.2 Storage and safe use of glasses

CH11.2.5.3 Safety supplies

CH11.2.5.4 Machine shop conditions

CH11.2.5.5 Elimination of fire and mechanical hazards

CH11.2.5.6 Emergency lighting and power

CH11.2.5.7 Maintenance and use of special safety equipment, such as ventilation systems, respirators, safety glasses, self-contained breathing apparatus, and air sampling equipment

CH11.2.5.8 Review of handling procedures involving toxic materials

CH11.3 Recommendations for the Safe Operation of Particle Accelerators

CH11.3.1 A responsible person for the particle accelerator facility shall be appointed as RPC (per the facility-specific OWI).

CH11.3.2 The accelerator facility shall be under the guidance of the RPC who shall be responsible for advising on radiation safety.

CH11.3.3 The operator of the accelerator shall be responsible for all operations connected with the accelerator, including radiation safety. The RPC shall have the authority to cease operations at the facility because of radiation safety considerations.

CH11.3.4 No individual shall be permitted to act as an operator of an accelerator until such person has: (a) received an acceptable amount of training in radiation safety as approved by the RPC; (b) demonstrated competence to use the accelerator, related equipment, and radiation survey instruments that will be employed; and (c) been approved by the RPC and OMEHS or RSO/RSC.

CH11.3.5 Operators and other appropriate personnel shall be familiar with and be given a copy of the written operating and

emergency procedures pertaining to radiation safety. Such procedures should be posted near the accelerator control console.

CH11.3.6 Particle accelerators shall be secured to prevent unauthorized use when not in operation.

CH11.3.7 Meters and controls on the accelerator control console shall be clearly identified and easily discernible.

CH11.3.8 All entrances into a target room or other high radiation area shall be provided with interlocks.

CH11.3.9 Only a switch on the accelerator control shall be used to turn the accelerator beam on and off. The safety interlock system shall not be used to turn off the accelerator beam, except in an emergency. If the interlock system does turn off the accelerator, it will not be possible to resume operation without resetting the accelerator "ON" switch at the control console.

CH11.3.10 All safety interlocks shall be dependent upon the operation of a single circuit.

CH11.3.11 A scram button or other emergency cutoff switch shall be located and easily identifiable in all high radiation areas. Such a cutoff switch shall include a manual reset so that the accelerator cannot be restarted from the accelerator control without resetting the cutoff switch.

CH11.3.12 Electrical circuit diagrams of the accelerator and the associated interlock systems shall be kept current and on file at each accelerator facility.

CH11.3.13 All locations designated as high radiation areas and entrances to such locations shall be equipped with easily observable flashing or rotating red or magenta warning lights that operate automatically when, and only when, radiation is being produced. Lights of a different color shall be used when other visual indicators are required.

CH11.3.14 All safety and warning devices, including interlocks, shall be checked at intervals not to exceed 1 month to ensure that they are functioning properly and are appropriately serviced. Permanent records shall be kept for a minimum of 3 years. Requirements shall be given in each facility’s OWIs.

CH11.3.15 Appropriate, portable radiation monitoring equipment, properly maintained and calibrated, shall be available at the accelerator facility and shall be sensitive to those radiations being monitored.

CH11.3.16 An appropriate radiation monitor shall be used within an accelerator target room and other high radiation areas. This may be: (a) an area monitor with an easily observable indicator that warns of radiation levels above a predetermined limit in accessible areas; and/or (b) a personal radiation monitor of the "chirpie" type carried into the room; and/or (c) a portable survey instrument carried into the room. Additional measures will be implemented to ensure that no inadvertent or unauthorized access is gained to very high radiation areas.

CH11.3.17 Personal radiation dosimeters that measure the expected radiations and that are of sufficient range to be useful under normal and accidental conditions shall be worn by all persons designated by the radiation protection supervisor.

CH11.3.18 Before a new installation is placed in routine operation, a radiation protection survey shall be made by a qualified expert.

CH11.3.19 A radiation protection survey shall be performed when changes have been made in shielding, operation, equipment, or occupancy of adjacent areas, and a survey shall be made periodically to check for unknown changes and malfunctioning equipment.

CH11.3.20 Records of all radiation protection surveys, inspections, and maintenance performed on the accelerator and related components shall be kept current and on file at each accelerator facility and shall be periodically reviewed by the RSO.

CHAPTER 12

RADIATION SAFETY TRAINING

CH12.1 General

Assurance of proper training and certification as required by MWI 3410.1 will be maintained through formalized training requirements for each employee whose regular job assignment involves work in areas involving radiation producing materials and or equipment. The training program will include the items discussed in the following paragraphs.

CH12.2 Indoctrination

CH12.2.1 Before an employee's assignment, the area supervisor will acquaint the employee with general radiation protection rules, procedures, etc. This may actually be in the form of a short course.

CH12.2.2 Before an employee begins work and before a TLD badge will be issued, he/she must attend a general orientation to radiation safety presented by the RSO or other properly qualified individual.

CH12.3 Field Instruction

Before an employee begins work, his/her supervisor will familiarize him/her with specific procedural and engineering safeguards employed in his/her specific work area.

CH12.4 Classroom Instruction

CH12.4.1 The RSO will conduct classes in radiation safety annually, including principles of radiation protection, policy and regulatory requirements, safe handling practices, and emergency procedures. A basic outline is included in CH12.5.

CH12.4.2 The RSO will conduct annual refresher training courses to update employees on the latest changes in procedures, equipment, problems in different types of machines, sources, etc. All training records will be maintained by the RSO.

CH12.5 Radiation Training Outline

CH12.5.1 Fundamentals of Radiation Safety:

CH12.5.1.1 Characteristics of gamma and x-radiation

CH12.5.1.2 Units of radiation dose (rem, sievert) and quantity of radioactivity (curie, becquerel)

CH12.5.1.3 Hazards of excessive exposure to radiation

CH12.5.1.4 Levels of radiation from sources or machines

CH12.5.1.5 Methods of controlling radiation dose:

a. Working time

b. Working distances

c. Shielding

CH12.5.2 Radiation detection instrumentation to be used

CH12.5.2.1 Use of radiation survey instruments:

a. Operation

b. Calibration

c. Limitations

CH12.5.2.2 Survey techniques

CH12.5.2.3 Use of personnel monitoring equipment:

TLD badges

CH12.5.3 The requirements of pertinent Federal regulations

CH12.5.4 The user’s written operating and emergency procedures

Chapter 13

NUCLEAR REGULATORY COMMISSION (NRC) LICENSING

CH13.1 NRC Licensing for MSFC

CH13.1.1 All operations involving radioactive material at MSFC are controlled by the NRC. The RSO and the Management Support Office are the official liaisons between the users, the NRC, and the RSC.

CH13.1.2 To obtain permission to use radioactive materials, it is necessary to submit NRC Form 313, Application for By-product Material License, to the NRC. The user will send to the RSO (in letter form or e-mail) sufficient information for completion of this form and subsequent submittal to NRC. The user will prepare the procurement request and route it through the RSO for review and approval. **NOTE: A LEAD TIME OF 3 TO 6 MONTHS IS NECESSARY TO OBTAIN AN NRC LICENSE**.

CH13.1.3 MSFC has an NRC License. This license is very limited in scope and application.

CH13.1.4 NRC licenses expire at different times, depending on the type of license. All license renewals are coordinated by the RSO.

CH13.1.5 The RSO is responsible for assuring that all shipments of radioactive materials to MSFC can be legally received.

CHAPTER 14

MSFC AS LOW AS REASONABLY ACHIEVABLE (ALARA) PROGRAM

CH14.1 Management Commitment

CH14.1.1 The management of MSFC is committed to the program described herein for keeping individual and collective dose as low as reasonably achievable. MSFC hereby describes an administrative organization for radiation safety and will develop the necessary written policy, procedures, and instructions to foster the ALARA concept within MSFC. The organization will include an RSC and RSO.

CH14.1.2 The RSO for MSFC will perform a formal annual audit of the radiation safety program, including ALARA considerations. This will include reviews of operating procedures and past dose records, inspections, etc., and consultations with the radiation safety staff or outside consultants. The RSO will report the results of the annual audit to the RSC.

CH14.1.3 Modifications to operating and maintenance procedures and to equipment and facilities will be made if they will reduce exposures unless the cost is considered to be unjustified (per agreement between the local supervisor, the RSC, and the Facilities Engineering Department Director). MSFC will be able to demonstrate, as necessary, that improvements have been sought, that modifications have been considered, and that they have been implemented when reasonable. If modifications have been recommended but not implemented, MSFC will be prepared to describe the reasons for not implementing them.

CH14.1.4 In addition to maintaining doses to individuals as far below the limits as is reasonably achievable, the sum of the dose received by all exposed individuals will also be maintained at the lowest practicable level. It would not be desirable, for example, to hold the highest doses to individuals to some fraction of the applicable limit if this involved exposing additional persons and significantly increasing the sum of radiation doses received by all involved individuals.

CH14.2 Radiation Safety Committee

CH14.2.1 The RSC will thoroughly review the qualifications of each applicant with respect to the types and quantities of materials and methods of use for which application has been made

to ensure that the applicant will be able to take appropriate measures to maintain exposure ALARA.

CH14.2.2 When considering a new use of byproduct material, the RSC will review the efforts of the applicant to maintain exposure ALARA.

CH14.2.3 The RSC will ensure that the users justify their procedures and that individual and collective doses will be ALARA.

CH14.2.4 The judicious delegation of RSC authority is essential to the implementation of a successful ALARA program.

CH14.2.5 The RSC will delegate authority to the RSO for implementation of the ALARA concept.

CH14.2.6 The RSC will support the RSO when it is necessary for the RSO to assert authority by the appropriate channels. If the RSC has overruled the RSO, it will record the basis for its action in the minutes of their meetings.

CH14.2.7 The RSC will encourage all users to review current procedures and develop new procedures as appropriate to implement the ALARA concept.

CH14.2.8 The RSC will perform an annual review of occupational radiation exposure with particular attention to instances in which the investigation level in Table 1 is exceeded. The principal purpose of this review is to assess trends in occupational exposure as an index of the ALARA program quality and to decide if action is warranted when investigation levels are exceeded (see Table 1 below for a discussion of investigation levels).

Table 1 Investigation Levels

		Level 1	
1.	Whole body	500 mRem/year	(5 mSv/year)
2.	Lens of the eye	1500 mRem/year	(15 mSv/year)
3.	Skin and extremities	5000 mRem/year	(50 mSv/year)

		Level 2	
1.	Whole body	1000 mRem/year	(10 mSv/year)
2.	Lens of the eye	3000 mRem/year	(30 mSv/year)
3.	Skin and extremities	10000 mRem/year	(100 mSv/year)

CH14.2.9 The RSC will evaluate MSFC's overall efforts for maintaining exposures ALARA on an annual basis. This review will include the efforts of the RSO, authorized users, and workers as well as those of management.

CH14.3 Radiation Safety Officer

CH14.3.1 The RSO will perform an annual review of the radiation safety program for adherence to ALARA concepts. Reviews of specific methods of use may be conducted on a more frequent basis.

CH14.3.2 The RSO will review at least annually the external radiation exposures of authorized users and workers to determine that their exposures are ALARA in accordance with the provisions of Table 1 of this program and will prepare a summary report for the RSC.

CH14.3.3 The RSO will review radiation levels in unrestricted and restricted areas to determine that they were at ALARA levels during the previous year and will prepare a summary report for the RSC.

CH14.3.4 The RSO will ensure that authorized users, workers, and ancillary personnel who may be exposed to radiation will be instructed in the ALARA philosophy and informed that management, the RSC, and the RSO are committed to implementing the ALARA concept.

CH14.3.5 Radiation workers will be given opportunities to participate in formulating the procedures that they will be required to follow.

CH14.3.6 The RSO will be in close contact with all users and workers to develop ALARA procedures for working with radioactive materials.

CH14.3.7 The RSO will evaluate the suggestions of individual workers for improving radiation protection and will encourage the use of those procedures.

CH14.3.8 The RSO will investigate all known instances of deviation from good ALARA practices and, if possible, will determine the causes. When the cause is known, the RSO will advise changes in the program to maintain exposures ALARA.

CH14.4 Authorized Users

CH14.4.1 The authorized user will consult with, and receive the approval of the RSC during the planning stage before using radioactive materials for a new method of use.

CH14.4.2 The authorized user will evaluate all methods of use before using radioactive materials to ensure that exposures will be kept ALARA.

CH14.4.3 The authorized user will explain the ALARA concept and the need to maintain exposures ALARA to all supervised persons.

CH14.4.4 The authorized user will ensure that supervised persons who are subject to occupational radiation exposure are trained and educated in good health physics practices and in maintaining exposures ALARA.

CH14.5 Persons Who Receive Occupational Radiation Exposure

CH14.5.1 Workers will be instructed in the ALARA concept and its relationship to work procedures and work conditions.

CH14.5.2 Workers will know what recourses are available if they feel that ALARA is not being promoted on the job.

CH14.6 Establishment of Investigation Levels to Monitor Individual Occupational Radiation Exposure

CH14.6.1 MSFC hereby establishes investigation levels for occupational external radiation doses, which, if exceeded, will initiate review or investigation by the RSC and/or the RSO. The investigation levels that have been adopted are listed in Table 1. These levels apply to the exposure of individual workers.

CH14.6.2 The RSO will review and record on NRC Form 5, “Current Occupational External Radiation Exposures,” or an equivalent form (e.g., dosimeter processor’s report) results of personnel monitoring at least annually as required by 10 CFR 20.2106. The following actions will be taken at the investigation levels as stated in Table 1:

CH14.6.2.1 Except when deemed appropriate by the RSO, no further action will be taken in those cases where an individual’s dose is less than Table 1 values for the Investigation Level 1.

CH14.6.2.2 The RSO will review the dose of each person whose annual dose equals or exceeds Investigation Level 1 and will report the results to the review at the first RSC meeting following the year when the dose was recorded. If the dose does not equal or exceed Investigation Level 2, no action related

specifically to the exposure is required unless deemed appropriate by the Committee. The Committee will, however, review each such dose in comparison with those of other performing similar tasks as an index of ALARA program quality and will record the review in the Committee minutes.

CH14.6.2.3 The RSO will investigate in a timely manner the causes of all personnel doses equaling or exceeding Investigation Level 2 and if warranted, will take action. A report of the investigation, and actions taken, and a copy of the individual's NRC Form 5 or its equivalent will be presented to the RSC at its first meeting following completion of the investigation. The details of these reports will be included in the RSC minutes.

CH14.6.2.4 In cases where a worker's or a group of workers' doses may exceed Investigation Level 2, a new Investigation Level 2 may be established on the basis that it is consistent with good ALARA practices for the individual or group. Justification for a new Investigation Level 2 will be documented.

CH14.6.2.5 The RSC will review the justification for and will approve all revisions of Investigation Level 2. In such cases, when the exposure equals or exceeds the newly established Investigation Level 2, those actions listed in Table 1 "Level 2" will be followed.

CH14.7 Radiation Safety Guidance

CH14.7.1 A Radiation Work Permit (RWP) will be prepared by the RSO for general or specific work evolutions when deemed necessary or advantageous by the RSO. The RWP shall include, as a minimum:

CH14.7.1.1 Work Location

CH14.7.1.2 Work description

CH14.7.1.3 Personal protective equipment

CH14.7.1.4 Dosimetry requirements

CH14.7.1.5 Special requirements

CH14.7.1.6 Personnel involved

CH14.7.2 The preparation of this RWP by the RSO, delivery to the user, and briefing of the appropriate personnel on the requirements shall alleviate the user of the requirement for preparing a radiation safety plan.

CHAPTER 15

VIOLATIONS

CH15.1 General

For the RSO to carry out his/her job effectively, the authority and means to prevent unsafe practices shall be granted. To assist in accomplishing this, there must be a series of instructions defining: (a) different categories of actions to which the RSO must respond and (b) the appropriate action necessary from the RSO in response, with backup from the RSC as necessary. These are of necessity, guidelines only, as the perception of risk is highly subjective. Nevertheless, the RSO is trained to assess such situations and make his/her best judgment regarding the appropriate category. The appropriate action is detailed below:

CH15.2 Minimum Risk

CH15.2.1 This category includes those actions that are non-hazardous violations of NRC regulations and procedures.

CH15.2.2 Verbal warning. If warning not heeded, then category is upgraded to medium.

CH15.3 Medium Risk

CH15.3.1 This category includes those practices that are in violation of NRC regulations and that, if continued, could eventually pose a health hazard or a moderate to serious regulatory concern. It also includes Minimum Risk category actions where the violator has ignored the RSO’s verbal warning.

CH15.3.2 The violation is documented in a standard memorandum and copies are sent to the violator, his/her immediate supervisor, MSFC Occupational Health Officer, RSC Chairperson, OMEHS COTR, and Contracting Officer’s Technical Representative (COTR), if violator is a contractor employee and Contracting Officer (CO). The memorandum will detail the nature of the violation, the remedial action necessary with an appropriate timescale, and will state the consequences of failure to comply. In most cases, failure to comply will result in loss of radiation badge privileges and/or shutting down of the equipment or facility (see Serious Risk Action below). The memorandum will also give the violator the opportunity to discuss matters with the Chairperson of the RSC, if they feel the action is unjustified or the timescale cannot be met. All findings will be

entered into the Environmental Health Services data base by the RSO and tracked.

CH15.4 Serious Risk

CH15.4.1 This category includes those violations that are considered an immediate health risk and/or a serious regulatory violation.

CH15.4.2 In these cases the RSO shall immediately shut down operations and revoke radiation privileges as appropriate. The violation is documented in the standard memorandum that gives details of the nature of the violation and the remedial action necessary. Copies of the memorandum are sent to the appropriate department manager and supervisors and personnel directly involved, as well as the RSC Chairperson, MSFC Occupational Health Officer, OMEHS COTR, and COTR, if violator is a contractor employee. An emergency session of the RSC will be called to review the case and recommend at what point operations can continue. The RSC authorizes continuation and reinstatement of radiation privileges as necessary, in the form of a memorandum when determined necessary requirements have been met. All findings will be entered into the Environmental Health Services data base by the RSO and tracked.